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Cover: This undescribed ant spider (Zodariidae), known only from the Expedition Range, is one of about 25 new *Habronestes* species from Queensland. In Australia, *Habronestes* is one of the most diverse genera of ant spiders with almost 130 species, of which only about one fifth are described. They are small to medium-sized spiders (2 – 12 mm in length) and most can be recognised by the bright yellow or orange spots on their backs and the distinctive palps of the males. Illustration by Barbara Baehr.

NEW DISTRIBUTION RECORDS FOR AUSTRALIAN BUTTERFLIES (LEPIDOPTERA)

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Abstract

New distribution records are provided for *Nacaduba biocellata* (C. & R. Felder), *Catopyrops florinda estrella* (Waterhouse & Lyell), *Theclinesthes serpentata serpentata* (Herrich-Schäffer) and *Catochrysops panormus platissa* (Herrich-Schäffer) [all Lycaenidae] from Broome, Western Australia, plus *Ocybadistes walkeri sothis* Waterhouse [Hesperiidae] from Stanley, Tasmania.

Introduction

Braby (2000), using notes and distribution maps, indicated the known distribution of all the Australian butterfly species then recorded. These maps were repeated in Braby (2004).

During July 2001 and February 2005, while holidaying in Broome, Western Australia and in Tasmania, respectively, several species were collected in localities that extend their previously known distributions.

New records

HESPERIIDAE

Ocybadistes walkeri sothis Waterhouse

One male was collected at Trethewies Lookout near Stanley, Tasmania, on 13.ii.2005. The Tasmanian distribution of this species was given by Braby (2000) as 'from sea level to about 230 m in the northern and eastern coastal areas, from Burnie to Bridport, and from Hobart to Lunawanna.' The above Stanley record extends the known distribution of *O. walkeri* Heron within Tasmania to some 80 km west of Burnie.

LYCAENIDAE

Nacaduba biocellata biocellata (C. & R. Felder)

Seven specimens were collected in Broome, WA: two males on 28.vii.2001, two males above Cable Beach on 27 & 29.vii.2001, one male and two females in the grounds of the Mercure Inn on 27.vii.2001. Braby (2000) indicated that this species 'occurs throughout most, and probably all, of mainland Australia ... [and] seems to be rarer in the tropics but has been recorded from near Mt Agnes in the Prince Regent River district, WA.' However, his distribution maps (Braby 2000, 2004) indicate that it has not been recorded previously within approximately 300 km of Broome.

Catopyrops florinda estrella (Waterhouse & Lyell)

Two males were collected in Broome, one on 30.vii.2001 and the other above Cable Beach on 29.vii.2001. This subspecies occurs sporadically across northern Australia, with the previous locality closest to Broome being north of the Edgar Range, *ca* 100-130 km SE of Broome (Braby 2000, 2004).

Theclinesthes serpentata serpentata (Herrich-Schäffer)

One male was collected in the grounds of the Mercure Inn, Broome, on 27.vii.2001. Braby (2000) noted that this species occurs 'throughout much of the mainland' but recorded it only as far north as Roeburne in Western Australia. The Broome record extends its distribution north by *ca* 600 km.

Catochrysops panormus platissa (Herrich-Schäffer)

Two males were collected above Cable Beach, Broome, on 29.vii.2001. In Western Australia this species 'occurs sporadically from the Mitchell Plateau and 12 km south of Kalumburu' (Braby 2000). The Broome record extends its distribution south by *ca* 600 km.

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BRABY, M.F. 2004. *The complete field guide to butterflies of Australia.* CSIRO Publishing, Collingwood; x + 340 pp.

LIFE HISTORIES OF *SCYMNUS BIPUNCTATUS* KUGELANN (COLEOPTERA: COCCINELLIDAE) AND *CHRYSOPA* SP. (NEUROPTERA: CHRYSOPIDAE): POTENTIAL AUGMENTATIVE BIOCONTROL AGENTS FOR THE MEALYBUG *DYSMICOCCUS BREVIPES* (COCKERELL) (HEMIPTERA: PSEUDOCOCCIDAE) IN VIETNAM

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Abstract

Mealybugs are serious pests of crops in Vietnam but there are several indigenous natural enemies that may be useful for their control. Life history data and the results of breeding trials are presented on two indigenous predator species, *Scymnus bipunctatus* Kugelann and *Chrysopa* sp. The suitability of both species for mass rearing and for release as augmentative biological control agents are assessed. Both predator species responded well under laboratory conditions and readily attacked the target species *Dysmicoccus brevipes* (Cockerell). Their high levels of fecundity, short generation times and high survivability in captivity suggest they might be successful when reared in adequate quantities for release in augmentative biological control programmes.

Introduction

One of the most serious pests of crops in Vietnam is the mealybug *Dysmicoccus brevipes* (Cockerell) (Waterhouse 1993a). It causes heavy damage in pineapple, coffee, mango, papaya, guava, banana, soursop and custard apple plantations, and imposes a financial burden on many communities. Mealybug infestations are difficult to eradicate because crawlers (larvae) wedge themselves in plant roots, crotches, slots of fruit and leaf folds where pesticides cannot reach them. Furthermore, side effects from the largely uncontrolled use of pesticides (*e.g.* Paul and Hai 1999) have resulted in contamination of the water table in some areas of Vietnam and excessive pesticide residues on food (Bien *et al.* 2000). Thus, the identification and utilisation of augmentative biological control agents for crop insect pests in Vietnam has become a priority (Cam 1995).

Fortunately, mealybug infestations have been successfully controlled in many countries using a variety of predators and parasites. For example, the ladybug *Cryptolaemus montrouzieri* Mulsant and a parasitic wasp, *Coccidoxenoides peregrinus* (Timberlake), were used to control the mealybug *Planococcus citri* (Risso) in Australia (Waterhouse and Sands 2001). *C. montrouzieri* was also introduced, together with the parasitic wasp *Anagyrus kamali* Moursi, to control the mealybug *Maconellicoccus hirsutus* (Green) in the Caribbean (Goolsby *et al.* 2002).

Mealybugs are so called because of the white waxy covering on their bodies that gives the impression they were rolled in flour. The wax helps protect them from excessive heat and moisture loss, and from contamination with their own excreta (Gullan and Cranston 2005). They secrete sticky honeydew that is attractive to nectar-seeking insects such as ants; however, excess honeydew adheres to leaf surfaces and attracts mould growth. Excessive mould growth is unsightly on the fruit and difficult to remove, and it can inhibit photosynthesis, thus weakening the plant (Elmer and Brawner 1975, McGavin 1993). Mealybugs feed on plant sap through a long, strawlike mouthpart, or stylet, after inserting it into the plant tissue. Damage to a plant is also caused by depletion of sap causing yellowing or loss of foliage and poor fruit set.

Classical biological control involves the importation and release of exotic control species. However, the use of endemic natural enemies where they exist is preferable because, for example, there is less likelihood of any impact on non-target species (Hoddle 2004). Augmentation and conservation of natural enemies is preferred and is an important first step in developing an integrated pest management scheme (Cam 1995). This paper documents life history data for two species of mealybug predators identified in Vietnam, namely the 'two-spotted ladybug' beetle *Scymnus bipunctatus* Kugelann and a green lacewing, *Chrysopa* sp. Both were reared in the laboratory at Nong Lam University, Ho Chi Minh City, as a preliminary study to test their suitability for mass rearing and for release as augmentative biocontrol agents for mealybugs in Vietnam.

Materials and methods

Fieldwork was undertaken by one of us (VTN) in Binh Chanh District, Ho Chi Minh City (10°46'N, 106°43'E), between August 2001 and March 2005, to locate and identify potential indigenous biological control agents for mealybug pests. Two mealybug predators, *Scymnus bipunctatus* and a *Chrysopa* sp., were reared successfully in breeding trials detailed below. Voucher specimens of *S. bipunctatus* (VTN-01 - larvae, VTN-02 - adults) and the *Chrysopa* sp. (VTN-03 - larvae, VTN-04 - adults) are lodged in the Research and Technology Transfer Centre, Nong Lam University, Vietnam, and additional specimens are lodged at La Trobe University in Victoria, Australia. Ants, including a small black species, were observed attending *D. brevipes* in the field but these have not been identified.

S. bipunctatus and the *Chrysopa* sp. were bred in the laboratory of Nong Lam University, Thu Duc District, Ho Chi Minh City, Vietnam, from August 2003 to September 2004 (*S. bipunctatus*), and from January to April 2004 (*Chrysopa* sp.). Large numbers of *D. brevipes* were reared on immature bananas in clear plastic breeding boxes (10.5 cm long x 7.5 cm wide x 4.5 cm high) with fine netting glued across a hole in the lid. Larvae of *S. bipunctatus* and *Chrysopa* sp. were reared separately on *D. brevipes* in these containers.

Slightly larger containers were used when pairing adults of *S. bipunctatus* and *Chrysopa* sp. for breeding and, in the boxes for breeding *Chrysopa* sp., some cotton-balls soaked in honey were provided as food for the adults. All food was changed daily except in the box containing adult *S. bipunctatus*, which was changed every five days. All experiments were conducted under ambient temperature and relative humidity.

In order to gauge the range of variability in life history and feeding parameters, four sets of experiments were conducted, each using 25 individuals (predators). Observations on developmental stages and the counting of eggs were conducted daily (*S. bipunctatus* eggs were counted every five days). Several parameters of the predator species were measured, including longevity, feeding rates, fecundity, survival rates and physical morphology. Survival rates for all predators were estimated by determining the proportion of adults that emerged from their pupae after completing their life cycles in captivity. The predacious effects of final instar larvae of *Chrysopa* sp. and *S. bipunctatus* on mortality of adult *D. brevipes* were calculated and corrected to the control mortality using Abbott's formula ($PT = (1 - T_A/C_A) \times 100$), where T_A is treatment survival and C_A is control survival (Abbott 1925). For this experiment, mealybugs were fed on China squash suspended in a net house 2.1 m x 1.5 m x 1.8 m high; there were three replicates of 10 *Chrysopa* sp. or 25 *S. bipunctatus* for each treatment. Daily temperature and relative humidity (RH) readings were taken, each record being the mean of three readings taken at 0630, 1130 and 1730 hrs. Temperature and RH per batch was the average taken from all breeding days. Morphological measurements and fecundity were measured on 30 individuals at an average temperature of 28.6 °C, RH 80.2% (April to September 2004).

Results

Field observations

Dysmicoccus brevipes was the most commonly encountered mealybug in the field. However, other pseudococcid pest species, such as *Ferrisia virgata* (Cockerell), *Planococcus lilacinus* (Cockerell), *P. citri*, *Maconellicoccus hirsutus* and *Rastrococcus spinosus* (Robinson), were also found. Several predator or parasitic species from at least four different orders were found attacking the mealybugs. These included *Eublemma amabilis* Moore (Lepidoptera: Noctuidae), *Spalgis epius* Westwood (Lepidoptera: Lycaenidae) and *Anagyrus ananatis* Gahan (Hymenoptera: Encyrtidae), in addition to the *Chrysopa* sp. and *S. bipunctatus* investigated in this study. Breeding trials were also undertaken with *E. amabilis* (with limited success) but the predacious butterfly *S. epius* could not be bred successfully. Additional trials were conducted to test the predators' feeding rates on *Ferrisia virgata* and *Planococcus lilacinus* but the results are not reported here. Several thousand specimens of *S. bipunctatus* and *Chrysopa* sp. were successfully reared during the course of this study.

Biology of Scymnus bipunctatus

In the wild, *S. bipunctatus* was commonly found attacking mealybugs, including *Ferrisia virgata, Maconellicoccus hirsutus, Planococcus lilacinus* and *P. citri*, in addition to *Dysmicoccus brevipes*. Lifespan of juvenile *S. bipunctatus* averaged between 26.9 and 30.1 days, depending on the season. During October-December (av. 27.5 °C and RH 82.7%), the life cycle appeared to be longer than during February-April (av. 28.3 °C and RH 69.3%), although the biggest increases occurred during the egg and pupal stages (Fig. 1). Egg and pupal stages of the life cycle were the longest, while duration of the second instar larva was the shortest (Fig. 1). *S. bipunctatus* moulted three times. Fourth instar larvae consumed an average of 2.1 *D. brevipes* adults per day (range 1-3).

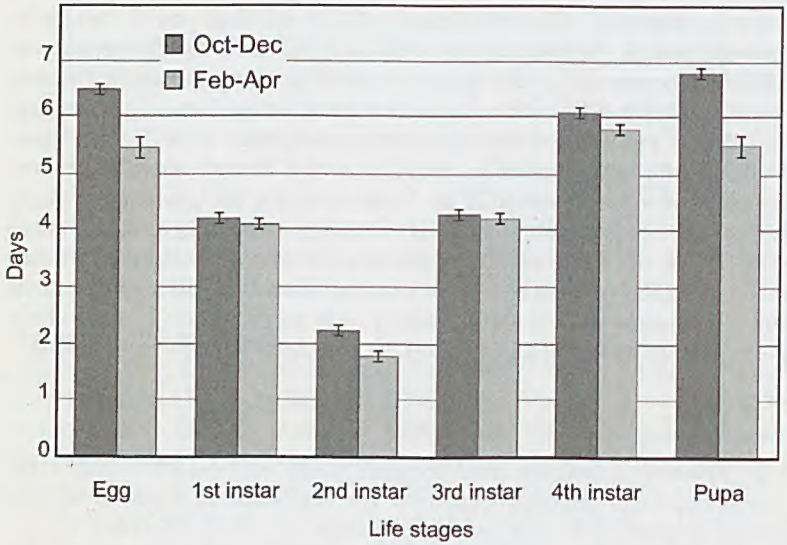

Fig. 1. Seasonal variation in the development times of *S. bipunctatus* early stages. Standard error bars shown.

Adult *S. bipunctatus* averaged 1.8 mm long (SE = 0.1) and 1.2 mm wide (SE = 0.1). When feeding on mealybugs, adult *S. bipunctatus* preferred to attack small larvae rather than large ones and they consumed an average of 63.4 (SE = 4.6, range 20-97) first instar *D. brevipes* larvae per day, or 1.6 final instar larvae per day. *S. bipunctatus* adult lifespan ranged from 30-163 days, with an average of 77.1 days (Table 1). Thus, under good conditions, each adult *S. bipunctatus* could eat nearly 5000 small *D. brevipes* larvae during its lifetime.

Once the small larvae were consumed, *S. bipunctatus* attacked mealybugs of any size. In the feeding trial, corrected prey mortality exceeded 95% by the third day (Table 2). Female *S. bipunctatus* laid an average of 222.3 eggs (SE = 11) at an average temperature of 28.6 °C and RH 80.2%.

Mean adult longevity increased during the course of the study and this was inversely related to humidity (Table 1); however, a correlation analysis found that the trend was non-significant (r = -0.724, $P = 0.27$), most likely due to the small number of datum points (n = 4). Overall survival rate of *S. bipunctatus* during the course of the study was 82.5%.

Table 1. Adult *Scymnus bipunctatus* longevity.

Batch	Temperature (°C)		Relative humidity (%)		Experiment duration	Adult stage (days)	
	$\bar{x} \pm$ SD	Range	$\bar{x} \pm$ SD	Range		$\bar{x} \pm$ SD	Range
1	28.0 ± 0.2	24.5-31.3	84.2 ± 0.9	74.5-90.7	19/8/03-22/11/03	63.1 ± 9.5	30-95
2	27.3 ± 0.1	24.5-29.2	75.4 ± 1.2	57.5-90.7	1/10/03-17/2/04	67.6 ± 16.8	32-139
3	27.4 ± 0.2	24.5-29.8	73.5 ± 1.0	57.5-90.7	20/10/03-22/3/04	77.6 ± 17.2	32-152
4	27.6 ± 0.2	25.0-31.2	72.5 ± 0.9	57.5-90.7	30/10/03-30/3/04	99.9 ± 19.3	39-163

Table 2. Cumulative effects of final instar larvae of *S. bipunctatus* and *Chrysopa* sp. on mortality of adult *D. brevipes*, corrected according to Abbott (1925).

Predator	Mortality %		
	Day 1	Day 2	Day 3
Chrysopa sp.	25.7	64.3	98.9
S. bipunctatus	21.3	60.8	95.8

Biology of Chrysopa *sp.*

The *Chrysopa* sp. studied here was found attacking *D. brevipes* in the wild, as well as other pseudococcid species, including *F. virgata*, *P. lilacinus* and *R. spinosus*. Lifespan of juvenile *Chrysopa* sp. averaged 20.2 (SE = 0.1) days at an average temperature of 29.5 °C and RH of 69%. The egg stage lasted 3 days, larvae fed for 8.5 days and the pupal stage lasted 8.7 days. Larvae underwent three moults, with the final stage lasting 2.8 (SE = 0.1) days. At an average temperature of 29.5 °C and 69% RH, *Chrysopa* sp. larvae consumed an average of 27.4 *D. brevipes* adults before pupating. Fourth instar larvae consumed the most, with an average of 18.8. Corrected prey mortality was

nearly 100% by the third day (Table 2). Some *Chrysopa* sp. larvae attacked *D. brevipes* 2-3 times longer and 7-8 times wider than themselves. Female *Chrysopa* sp. laid an average of 53.8 eggs (range 33-110), with approximately 98.3% viable. Overall survival rate of *Chrysopa* sp. was 78.9% during the breeding trial period.

Discussion

Both predator species investigated in this study performed well under laboratory conditions and both have potential as augmentative biological control agents. They exhibited high levels of fecundity as well as short generation times (r-strategists), and their high levels of survivability in captivity (*S. bipunctatus* 82.5%, *Chrysopa* sp. 78.9%) suggests they might be successfully reared in large quantities. Other closely related *Chrysopa* and *Scymnus* spp. have been reared in captivity overseas, and have been successfully released as augmentative and classical biological control agents (Quayle 1941, Brader 1979, van Lenteren 1997, Flint and Dreistadt 1998, Vail *et al.* 2001).

Importantly, since *S. bipunctatus* and *Chrysopa* sp. attack other target species, such as *F. virgata*, they also may be effective at controlling these species or they may be bred on alternative hosts, including *F. virgata*, if *D. brevipes* numbers are small prior to the peak activity selected for optimal release times (or *vice versa*). For example, in Java *Scymnus* spp. are not normally numerous enough to control *P. citri* until the end of the dry season; however, they can be bred in large numbers during the rainy season on *P. lilacinus* and liberated against *P. citri* at the beginning of the dry season (DeBach and Hagen 1970). Variation in life history characteristics according to changes in ambient temperature and humidity, observed in both species, has been noted previously in biocontrol agents (*e.g.* Waterhouse 1993b), so captive breeding facilities can manipulate parameters such as diapause or eclosion times to capitalise on optimal release times. For example, diapausing adults of *Chrysoperla* (= *Chrysopa*) may be stored for up to 30 weeks at low temperatures (Tauber *et al.* 1993), and *S. bipunctatus* fecundity can be manipulated to optimize seasonal innoculations at crucial times during the life cycle of the pest (van Lenteren 2000).

These breeding trials are an essential first step for identifying natural candidates for augmentative biological pest control. Field trial release of these control agents is the next step in gauging their effectiveness *in situ*, and in determining the timing and optimal numbers to be released. It is also known that the attendant ants of *D. brevipes* (and other mealybugs) can act as a deterrent to potential biological control agents (González-Hernández *et al.* 1999, Williams and Watson 1990), so adequate measures to reduce or exclude ants from climbing trees infested with mealybugs need to be investigated. The findings in this study are encouraging, and it is hoped that

mass rearing of *S. bipunctatus* and the *Chrysopa* species will provide a foundation for a biological pest management programme for the control of mealybug pests in Vietnam.

Acknowledgements

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BEHAVIORAL OBSERVATIONS ON AUSTRALIAN STILETTO FLIES (DIPTERA: THEREVIDAE) FROM SOUTHEASTERN NEW SOUTH WALES

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Abstract

Despite many years of study, there are few detailed reports on the behaviour of Australian stiletto flies. Over the past three years, a number of sites in southeastern New South Wales and the Australian Capital Territory were visited regularly to collect insects. Field observations on the Therevidae made at those sites are reported and discussed here.

Introduction

There are few detailed records of adult therevid behaviour in the field. White (1915) mentioned 'a silvery shimmering tomentum that covers all or part of the dorsal surface of the abdomen. This makes the male very conspicuous when in flight'. The website on Australasian Therevidae (Winterton *et al.* 2005) mentions a number of therevid behaviours, including hovering, swarming, attraction to water, nocturnal flight and attraction of some species to light traps. Over the 2003/04 and 2004/05 collecting seasons, therevids were collected and photographed, many of which can be found on the aforementioned website. The senior author regularly visited a number of sites and field observations of many different species of stiletto flies (Table 1) from those visits are provided here. Several of the species discussed are currently undescribed. Specimens collected from all the sites mentioned were identified, databased and housed in the Australian National Insect Collection at CSIRO Black Mountain, Canberra.

Observations

Bonython

Many detailed observations of therevid behaviour were made in a garden in Bonython (35°26'S, 149°04'E), a suburb of Canberra, Australian Capital Territory, where a large native garden was established in 1990. In 2000 a thick layer of river sand was placed over an old leaf litter surface of the property. In subsequent years, additional leaf litter has created a soil profile of sandy humus over clay. Six species of Therevidae, belonging to five genera, have been observed and 55 specimens collected from this garden over 4 years (Table 1).

Many male *Ectinorhynchus* sp. 1 (Fig. 1) were observed flying in sunny, warm weather from late September to mid-November. Two small areas, each about 2 m in diameter and only 10 m apart, frequently attracted swarms of males. The swarms were always low, 20-50 cm above ground. At times, as many as ten individuals occupied an area of about 1 m^2. Activity was greatest from mid-morning to early afternoon. Sometimes, individuals were as close

Table 1. Therevids collected at water or hand swept. Locations: B = Bonython, C = Corin Dam Road, G = Gilmore, J = Mt Jerrabomberra, K = Kambah, R = Broulee Island Nature Reserve, T = Tallaganda National Park.

Taxon	Nos.	At water			Netted		
		site	♂	♀	site	♂	♀
Acraspisa Kröber sp.	**9**	T	1	5	J B	2	1
Acraspisoides helviarta Hill & Winterton (Fig. 4)	**15**	T	2	10	T	2	1
Acupalpa albitarsa Mann	**9**	K		1	J	5	3
Acupalpa semirufa Winterton & Irwin (Fig. 3)	**2**				J	1	1
Agapophytus antheliogynaion Winterton & Irwin	**7**	T	5	2			
Agapophytus biluteus Winterton & Irwin (Fig. 2)	**4**	T	3	1			
Agapophytus palmulus Winterton & Irwin	**2**	T	2				
Agapophytus queenslandi Kröber	**11**	T	8	1	T		2
Anabarhynchus carduus Lyneborg	**6**				R	3	3
Anabarhynchus dimidiatus (Macquart)	**1**	T		1			
Anabarhynchus helvenacus White	**1**	T	1				
Anabarhynchus hyalipennis (Macquart)	**5**	C K	4	1			
Anabarhynchus maritimus Hardy	**3**				R	2	1
Anabarhynchus niveus Lyneborg	**7**	K		1	B G	1	5
Anabarhynchus paramonovi Lyneborg	**1**	C	1				
Anabarhynchus plumbeoides Lyneborg	**3**	K		1	B G		2
Belonalys obscura Kröber	**4**	T		4			
Bonjeania actuosa (White)	**26**	T	5	21			
Bonjeania clamosis Winterton & Skevington	**1**				B	1	
Bonjeania Irwin & Lyneborg sp. 1	**6**				G	4	2
Bonjeania Irwin & Lyneborg sp. 2	**1**	T		1			
Ectinorhynchus Macquart sp. 1 (Fig.1)	**19**				B	17	2
Ectinorhynchus sp. 2	**16**	K	2	3	B	11	
Ectinorhynchus phyciformis White	**20**	T	6	2	T	6	6
Ectinorhynchus pyrrhotelus (Walker)	**8**				R	6	2
Laxotela hauseri Winterton & Irwin	**10**	T	8	2			
Laxotela Winterton & Irwin sp. 1	**4**				T	2	2
Nanexila gracilis (Mann)	**2**				T	1	1
Neodialineura Mann sp. 1	**21**				B	20	1
Neodialineura Mann sp. 2	**10**	T		7	T	2	1
Neodialineura Mann sp. 3	**8**				G J	4	4
Parapsilocephala Kröber sp. 1	**1**				T		1
Parapsilocephala Kröber sp. 2	**1**				R	1	
Pipinnipons fascipennis (Kröber)	**7**	T	5		T		2
Pipinnipons Winterton sp. 1	**2**	T	2				
Taenogerella elizabethae Winterton & Irwin	**3**	K		2	J		1
Taenogerella platina Winterton & Irwin	**5**				J G	2	3
TOTAL	**261**		55	66		93	47

as 20 cm from one another. The hind legs hang beneath the body during flight, giving the fly a wasp-like appearance. When observed from a standing position, the silver abdomens of males (Fig. 1) are highly visible. As they change position there are flashes of silvery shimmer. From time to time they would all land, to rest on grass or herbage. This resting behaviour was interrupted if another male arrived, or one was disturbed, and all took flight. Occasionally, a male would chase another away from the swarm for several metres before returning.

Figs 1-4. Various Therevidae specimens, collected by D. Ferguson, photographed by C. Lambkin using techniques described by Fisher and Gaimari (2004). (1) Male *Ectinorhynchus* sp. 1 collected at Bonython, Sept. 2004, displaying silver tomentum on abdomen; (2) *Agapophytus biluteus* collected at mud at Tallaganda NP, Feb. 2004; (3) *Acupalpa semirufa* collected at Mt Jerrabomberra, Nov. 2004; (4) *Acraspisoides helviarta* collected at mud at Tallaganda NP, Dec. 2003.

Ectinorhynchus sp. 1 was only observed swarming at the garden in Bonython. While 19 specimens were collected, more than three times that number were observed. Females were rarely seen, presumably resting in the canopy of surrounding trees. Two females were observed in the cool of the morning on low foliage and collected (Table 1). An aerial mating was observed when a female flew from nearby tree foliage and tumbled with a male in the swarm, and then both flew, in copula, back toward the trees.

Ectinorhynchus phyciformis males were observed in the same garden in Bonython, in the mid to late afternoon, flying 4-6 m above ground in the space between trees. Individuals flew randomly in an area 40-50 cm in diameter, with hind legs hanging down. As the hind legs have a shining white basitarsus, *E. phyciformis* is easy to observe when behaving in this manner. *E. phyciformis* spends more time resting on foliage than actively flying. Occasionally, a male chased an *Ectinorhynchus* sp. 2 away before returning to the same leaf or rejoining the swarm.

Male *Ectinorhynchus* sp. 2 were observed flying in the Bonython garden from early to late afternoon during December 2004 and January 2005. This species flew 3-4 m above ground in the spaces between trees, at a lower level in the canopy than *E. phyciformis*. Individuals of *Ectinorhynchus* sp. 2 flew in a small space around 30-40 cm in diameter. Other males performed the same dancing behaviour a short distance away. Occasionally, if a male's dance space moved too close to another's, the second male chased the infringing male away for some distance before returning. Sometimes, a male would land on a leaf and rest. A large number of individuals were observed and 11 males collected (Table 1).

Males of *Neodialineura* sp. 1 were first observed in the Bonython garden in December 2004 and then repeatedly throughout January 2005. Individuals flew every day in swarms about 2 m above the ground, from early to late afternoon, on the western side of a *Eucalyptus* tree. Swarms ranged from only a few to as many as a dozen males. Generally the swarms were compact, occupying an area 50-60 cm in diameter, and were very active. These flies are small, less than 6 mm in length. If not for the silvery shimmer of the male abdomens, they would be very difficult to observe. Large numbers of *Neodialineura* sp. 1 were observed and 21 collected (Table 1).

Tallaganda National Park

Tallaganda National Park lies east of Hoskinstown, New South Wales, at an altitude of 1130 m (35°24'47"S, 149°32'22"E GPS). The environment is wet sclerophyll forest on decomposed granite substrata with a rich humus surface soil. Tall *Eucalyptus* trees tower above an intermediate storey dominated by *Acacia melanoxylon* R.Br. interspersed with *Banksia marginata* Cav. Ground cover is comprised of *Lomandra longifolia* Labill., *Dianella tasmanica* Hook.f. and *Pteridium esculentum* (G.Forst.) Cockayne. Areas of grassy

meadow, fringed by clumps of *Gahnia sieberiana* Kunth, surround patches of *Epacris microphylla* R.Br. The ground has a high load of very old, weathered, fallen timber, indicating that there have been no wild fires for many decades.

Many species of Therevidae have been observed and collected in this environment. During the summer months, between November 2003 and January 2005, 142 specimens from 19 species in 12 genera were collected (Table 1). In January 2004, after a prolonged hot, dry period, the damp mud at the bottom of a man-made reservoir was very attractive to a large number of therevids of many genera. Fifteen of the 19 species recorded in the area were collected at mud (Table 1). *Acraspisa* sp., *Acraspisoides helviarta* (Fig. 4) and *Pipinnipons fascipennis* would land some distance from the wet area and walk towards the moisture, but were always easily disturbed by sudden movements of the observer. In contrast, *Anabarhynchus* sp., *Belonalys obscura*, *Bonjeania actuosa*, *Ectinorhynchus phyciformis* and *Laxotela hauseri* would alight in the middle of the mud and, once settled and quietly drinking, were not disturbed by sudden movements. Activity around the moisture reached a peak around midday and throughout the early afternoon. No therevids were observed when the reservoir was completely dry. On a follow-up visit, two 20 litre containers of water were taken and emptied to recreate a damp base. Within minutes, high activity levels resumed. Four specimens of the rare *Agapophytus biluteus* (Fig. 2), described from only two specimens from Mittagong, NSW and Blundell's, ACT (Winterton and Irwin 2001), were collected over three occasions at the mud at the reservoir.

Pipinnipons fascipennis specimens were taken on a flowering *Baeckea utilis* F.Muell. ex Miq. and on *Persoonia* sp. growing near the reservoir in January 2004 and 2005. In the same area, two female *Agapophytus queenslandi* were collected after being observed sunning on old, weathered, fallen timber in December 2004 and January 2005. *Nanexila gracilis* was swept from *Lomandra longifolia* in the shade of tall *Acacia melanoxylon* trees in December 2004. On a hot and humid December afternoon in 2003, during the build-up to a large electrical storm, 10-12 adults of *Ectinorhynchus phyciformis* were observed sheltering on the base and lower branches of *Baeckea utilis*, a small shrub growing in a forest clearing. These might have been freshly emerged rather than sheltering from the pending storm.

Mt Jerrabomberra

At the summit of Mt Jerrabomberra (35°22'S, 149°13'E), near Queanbeyan, New South Wales, many *Acupalpa albitarsa* and three *Taenogerella platina* (including a mating pair) were swept from tree and shrub foliage in late 2003. Flowering *Cassinia quinquefaria* R.Br. attracted *Acupalpa albitarsa* in December 2002 and *T. elizabethae* and *Acraspisa* sp. in December 2004. Also in December 2004, a male *Acupalpa albitarsa* was swept from flowering *Kunzea ericoides* (A.Rich.) Joy Thomps. and two female *T. platina*

were collected sweeping over stony ground devoid of vegetation.. A female *Acupalpa semirufa* (Fig. 3) was swept from flowers of *Leptospermum multicaule* A. Cunn. in November 2004.

Broulee Island

Broulee Island (35°52'S, 150°11'E), on the south coast of New South Wales, is connected to the mainland by a 200 m sand spit. A small island rises steeply from a basalt rock shelf to form an almost flat, triangular plateau of rich sandy loam, approximately 700 m x 600 m in area, 27 m above sea level. Vegetation is a mix of *Casuarina glauca* Sieber ex Spreng., *Banksia integrifolia* L.f., *Rapanea* sp., *Elaeodendron australe* Vent., *Acacia mearnsii* De Wild. and *Acmena smithii* (Poir.) Merr. & L.M.Perry. The understorey is of *Acacia longifolia* subsp. *sophorae* (Labill.) Court, *Lomandra longifolia*, *Pteridium esculentum* and grasses. On an initial visit to the island four *Ectinorhynchus pyrrhotelus* were captured. On a second visit, further sampling was done over the whole island and a further four specimens were taken, including a mating pair. All the specimens were caught in an area of young *Rapanea* plants growing on the west of the island. A male *Parasilocephala* sp. 2 was collected on foliage of *Banksia integrifolia*. *Anabarhynchus maritimus* and the more numerous *An. carduus* were observed at rest on the sand spit and flew a short distance when disturbed.

Gilmore

A ridge east of Gilmore (35°25'S, 149°08'E), a suburb of Canberra, supports a dry sclerophyll forest. *Anabarhynchus niveus* and *Bonjeania* sp. 1 were collected amongst the understorey on the lower slopes. At the summit of 840 m, a male *Taenogerella platina* was swept from high in the foliage of an *Acacia melanoxylon*. Also at the summit, a mating pair of *Neodialineura* sp. 3 was noticed because of the flash of the male's silver tomentum. After they were disturbed into flight from their resting place on stony ground, the pair flew a short distance before landing back on the stones. Another two *Neodialineura* sp. 3 were swept from shrubs at the summit.

Kambah

Five *Ectinorhynchus* sp. 2 were found dead in a backyard swimming pool in the suburb of Kambah, ACT, in December 2003 and February 2004. From the same pool, two *Taenogerella elizabethae* and single specimens of *Acupalpa albitarsa, Anabarhynchus hyalipennis* ssp. *hyalipennis, An. niveus,* and *An. plumbeoides* were collected in February 2004 (Table 1).

Corin Dam Road

In March 2005, one *Anabarhynchus paramonovi* and four *An. hyalipennis* (Table 1) were collected at roadside puddles at 1220 m elevation on the Corin Dam Road (35°32'S, 148°53'E), 37 km SW of Canberra. Free-standing puddles were very attractive to adults, while the interconnected, slowly drained pools were not.

Discussion

Flies are often attracted to water, especially those whose immatures develop in aquatic environments, such as mosquitoes and midges. Because of this behaviour, pan traps, bowls or trays filled with water containing a small quantity of detergent or preservative (Southwood 1966) have been used to collect flies (Edwards and Huryn 1996, Kawaguchi and Nakano 2001). The attraction to water of flies with terrestrial immatures has been noted in the Bombyliidae (Lambkin *et al.* 2003) and Therevidae (Winterton *et al.* 2005).

Insects have often been recorded accumulating in numbers near water. This behaviour is common in butterflies, where it has been termed mud-puddling (Beck *et al.* 1999, Boggs and Jackson 1991, Shreeve 1987). However, in most butterfly species only males puddle (Beck *et al.* 1999, Molleman *et al.* 2004, Sculley and Boggs 1996). The nutrient most commonly considered to be the puddling stimulus for this behaviour in male butterflies is sodium (Beck *et al.* 1999, Molleman *et al.* 2004, Smedley and Eisner 1996), but there is also evidence for a role of nitrogen-rich compounds such as proteins (Beck *et al.* 1999), or those found in carnivorous animal dung (Boggs and Dau 2004). Studies on the effect of sodium in the diet of mud-puddling male Lepidoptera are contradictory. Molleman *et al.* (2004) were unable to find any significant effect on female reproductive output or any evidence that sodium acts as a nuptial gift in butterflies. However, earlier studies on moths (Smedley and Eisner 1996) found that sodium absorbed during mud-puddling was provided as a nuptial gift in the spermatophore and passed to the eggs. Alternatively, Hall and Willmott (2000) found evidence that suggested some riodinid butterflies mud-puddle to provide necessary nutrients to maintain high metabolic rates during rapid flight.

Attraction of adult flies to puddles of water has recently been reported in the Australian Therevidae (Winterton *et al.* 2005). Detailed observations from two locations are given in this study. The preferential attraction of free-standing puddles, compared with interconnected, slowly drained pools observed at Corin Dam Road, may be due to an accumulation of trace elements or salts. If therevids are also seeking sodium or nitrogenous compounds, those resources would be concentrated in smaller free-standing puddles, whereas flowing water would leach these substances, reducing their concentration in the connected pools.

In the Therevidae, attraction to puddles of water is not confined to males (Table 1). Male therevids do not transfer sperm in a spermatophore. However, in the Therevidae, females possess an unusual reproductive structure, a spermathecal sac (Winterton *et al.* 1999) that is only found in therevids and three related families of Diptera (Apsilocephalidae, Ocoidae and Scenopinidae). In the Australian Therevidae this structure is often voluminous, complex, multi-lobed, or made up of three entirely separate sacs. Winterton *et al.* (1999) suggested that the spermathecal sac might store a

nuptial gift from the male. As sperm have been found in the spermathecal sacs of some Australian Therevids (Winterton *et al.* 1999), it is more probable that the sacs act as an intermediate storage for sperm. Further investigation of this sac and its possible relationship with nutrient receipt and storage are needed.

Since both males and females are attracted to puddles (Table 1), it is possible that therevids are seeking extra nutrients to maintain high metabolic rates during rapid flight, as Hall and Willmott (2000) found in riodinid butterflies. Alternatively, as more females than males are observed at puddles (Table 1), females may be absorbing either sodium or nitrogenous compounds to aid in egg development.

Observing therevids in the field is generally difficult as they are alert, easily disturbed and move quickly and erratically. Thus sightings are generally brief. Swarming males are most easily observed. Male *Ectinorhynchus* and *Neodialineura* sp. 1 display in communal swarms, taking advantage of clearings with good light, at the expense of increased distance from females in the canopy. All female therevids, and males of *Bonjeania*, *Nanexila* and *Parapsilocephala*, are more drab, not having silvery tomentum covering the dorsal surface of the abdomen, and do not display; therefore they are more difficult to observe. Despite this, large numbers of these genera may be seen in specific locations.

Net-sweeping of foliage proved a productive way of sampling. Fourteen species were hand netted only and 12 species were collected only at mud or water. Eleven species were swept as well as being collected at mud or water. Netting from swarms collected large numbers of males. Sweeping generally produced more than twice as many males as females.

Many species, including *Acraspisa* spp., *Acupalpa albitarsa*, *Taenogerella platina*, *T. elizabethae* and *Neodialineura* sp. 3, have been collected on hill tops. Hilltopping behaviour has previously been observed in several groups of Australian flies, including bee flies (Bombyliidae) (Lambkin *et al.* 2003, Yeates and Dodson 1990) and big-headed flies (Pipunculidae) (Skevington 2001). *Patanothrix wilsoni* (Mann) males have been recorded hilltopping on large sand dunes in Wyperfeld National Park, Victoria (Winterton *et al.* 2001).

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NEW RECORDS OF HAWK MOTHS AND BUTTERFLIES (LEPIDOPTERA) FROM LIZARD ISLAND, NORTHERN QUEENSLAND

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Abstract

New records are provided for two species of hawk moths, plus nine species and one form of butterflies, from Lizard Island, northern Queensland. Notes on abundance are included.

Introduction

Prior to 2004, the hawk moths and butterflies of Lizard Island (off the north Queensland coast, about 93 km NNE of Cooktown) were poorly documented. Moulds (1985) recorded two species of hawk moths, *Macroglossum micaceum micaceum* (Walker) and *M. prometheus lineatum* (Lucas), while Duckworth and McLean (1986) listed 11 species of butterflies. Lachlan (2004) provided records for a further 17 species of hawk moths and 12 species of butterflies.

A second survey of Lizard Island was carried out by the author between 29 March and 8 April 2005. It followed the wet season but little rain had fallen in the previous month and continuous strong winds hampered the survey, as some parts of the island could not be reached.

Voucher specimens are temporarily in the author's collection; duplicates are held by the Queensland Museum, Brisbane, the Australian Museum, Sydney and the Australian National Insect Collection, CSIRO, Canberra.

Discussion

Table 1 details the new records. These comprise two species of hawk moths and nine species of butterflies. A second form of a previously recorded butterfly species was also collected. Unlike the first survey, which was carried out after a very severe drought, this second survey was conducted a month after the wet season. Butterflies were more numerous, particularly lycaenids, but they were mostly previously documented species. Perhaps the most interesting records from this second survey were *Petrelaea tombugensis* (Röber), noted by Braby (2000) as being uncommon within Australian limits, and *Nacaduba berenice berenice* (Herrich-Schäffer), which has not been recorded previously between Cooktown and Iron Range. Duckworth and McLean (1986) recorded an unnamed *Theclinesthes* Röber sp., which might be the same species (*T. miskini eucalypti* Sibatani & Grund) recorded during this survey.

It was surprising to note that the overall abundance of hawk moths was well down compared with the first survey. It was also interesting to note that no specimens have yet been taken of *Psilogramma* Rothschild & Jordan. This genus is very common along the Queensland coast and on islands of the

Torres Strait. The rarely encountered *Gnathothlibus australiensis* Lachlan, recorded by Lachlan (2004, as *Gnathothlibus* Wallengren sp.), was not recorded during the second survey. One female of *Macroglossum prometheus lineatum*, last recorded by Moulds (1985), was collected during the second survey.

Twenty-one species of hawk moths and 32 species of butterflies have now been recorded from Lizard Island.

Table 1. List of hawk moths and butterflies collected on Lizard Island during the March–April 2005 survey, additional to those recorded by Lachlan (2004). All are new species records except *Belenois java teutonia* (first record of pale form).

Species	Notes
HAWK MOTHS	
Sphingidae	
Hippotion boerhaviae (Fabricius)	Abundant
Hippotion rosetta (Swinhoe)	Two males, two females
BUTTERFLIES	
Hesperiidae	
Suniana sunias rectivitta (Mabille)	Two specimens
Pieridae	
Eurema alitha (C. & R. Felder)[1]	Not uncommon
Belenois java teutonia (Fabricius)	Pale form, one male
Nymphalidae	
Junonia orithya albocincta Butler	Not common, along beach areas
Danaus petilia (Stoll)[2]	Not common
Lycaenidae	
Nacaduba berenice berenice (Herrich-Schäffer)	One female
Petrelaea tombugensis (Röber)	One male
Jamides phaseli (Mathew)	Not common
Theclinesthes miskini eucalypti Sibatani & Grund	One female
Catochrysops panormus platissa (Herrich-Schäffer)	Common

[1]The subspecific status of Australian specimens has not yet been determined (Braby 2000); [2]The specific status of this species was discussed by Lushai *et al.* (2005).

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NOTES ON THE HAWK MOTHS AND BUTTERFLIES (LEPIDOPTERA) OF THE COCOS (KEELING) ISLANDS, INDIAN OCEAN

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Abstract

Records are provided for six species of hawk moths and eight species of butterflies from the Cocos (Keeling) Islands, including two newly recorded species, *Hippotion rosetta* (Swinhoe) (Sphingidae) and *Nacaduba biocellata biocellata* (C. & R. Felder) (Lycaenidae). Notes on abundance are included.

Introduction

The Cocos (Keeling) Islands are an external Territory of Australia and are situated in the Indian Ocean between 11°49'-12°12'S and 96°49'-96°56'E, about 2765 km north-west of Perth, Western Australia and 1100 km south-west of the western tip of Java, Indonesia. The nearest land mass is Christmas Island, about 950 km ENE. Two atolls make up the group of 27 islands. North Keeling Island is a National Park, uninbabited and approximately 24 km north of the southern, horseshoe-shaped group of islands. The total land area is only about 14 km^2 and no part of any island is higher than 6 m above sea level.

The islands are heavily covered by coconut palms (*Cocos nucifera*) and are generally fringed on their seaward sides by *Messerschmidia, Scaevola taccada, Hibiscus tiliaceus, Cordia subcordata, Calophyllum inophyllum, Guettarda speciosa, Morinda citrifolia* and *Pisonia grandis*. At least 43 indigenous plant species have been recognised. (Renvoize 1979).

This survey was carried out between 9 December 2004 and 6 January 2005; a total of 29 days and 28 nights. All the islands were very dry and no rain of note had fallen for several weeks prior to the survey period. Almost no rain was recorded during the survey. Voucher specimens are in the author's collection; some duplicates are held by the Australian Museum, Sydney.

Discussion

Several notable attempts have been made previously to document the Lepidoptera of the Cocos (Keeling) Islands. Wood-Jones (1909) recorded some 32+ species during a 15 months stay on the islands between 1905 and 1906, including four species of hawk moths, *Agrius convolvuli* (Linnaeus), *Cephonodes picus* (Cramer), *Macroglossum corythus* Walker and *Hippotion velox* (Fabricius), and five species of butterflies, *Hypolimnas bolina* (Linnaeus), *H. misippus* (Linnaeus), *Junonia villida* (Fabricius), *Vanessa kershawi* (McCoy) and *Danaus petilia* (Stoll).

T.G. Campbell made extensive Lepidoptera collections in 1952 and 1964, yet collected just three species of butterflies, one of which, *Euploea core corinna*

(W.S. Macleay), was a new record, and three species of hawk moths, *A. convolvuli, C. picus* and *M. corythus*. Specimens from these surveys were deposited in the Australian National Insect Collection, CSIRO, Canberra. (Holloway 1982).

In July 1978, M. and F. Jowett collected on West Island for two weeks with a small light trap and recorded one additional species of hawk moth, *Hippotion boerhaviae* (Fabricius) (Holloway 1982). D'Abrera (1986) queried the Cocos Islands as the type locality for the lycaenid *Catopyrops ancyra exponens* (Fruhstorfer) and did not illustrate it. Braby (2000) recorded this species from the Cocos (Keeling) Islands without comment and also did not illustrate it. This listing brought the total of recorded butterfly species to seven.

Despite the fact that the present survey focused entirely on the hawk moths and butterflies of these islands, only three species of hawk moths and five species of butterflies were collected. No other species were sighted. The full list of species collected is given in Table 1, together with notes on abundance. One species of hawk moth, *Hippotion rosetta* (Swinhoe), and one species of butterfly, *Nacaduba biocellata biocellata* (C. & R. Felder), are newly recorded. *N. b. biocellata* was only collected from one very small area on Home Island and was not seen anywhere else on that island or on any of the other islands. The specimens collected were compared with photographs of the types of *N. b. baliensis* Tite from Indonesia, but they are not this subspecies and are indistinguishable from specimens of *N. b. biocellata* from Australia, including NW Western Australia.

Table 1. List of species of hawk moths and butterflies collected on the Cocos (Keeling) Islands from 9 December 2004 to 6 January 2005. An asterisk (*) indicates a new record for the islands.

Species	Notes
HAWK MOTHS	
Sphingidae	
Agrius convolvuli (Linnaeus)	One male
Cephonodes picus (Cramer)	24 males, five females
Hippotion rosetta (Swinhoe) *	Four males, one female
BUTTERFLIES	
Nymphalidae	
Hypolimnas bolina nerina (Fabricius)	Six males, one female
Junonia villida (Fabricius)	Common
Vanessa kershawi (McCoy)	One female
Euploea core corinna (W.S. Macleay)	Very common
Lycaenidae	
Nacaduba biocellata biocellata (C. & R. Felder) *	30 males, three females

It is interesting to note that seven of the eight recorded butterfly species are Australian, despite the islands being much closer to Indonesia. The presence of the only non-Australian taxon, *Catopyrops ancyra exponens*, remains unconfirmed. Unlike Christmas Island, no endemic butterfly species has yet been recorded.

Acknowledgements

I sincerely thank Dr David Britton and Dr Max Moulds (Australian Museum, Sydney) for the loan of specimens in the AM collection and for comments on the manuscript, respectively. I particularly thank Katima Sloan of the Cocos (Keeling) Islands Tourism Association for all her help during the organising phase of the survey as well as all her help whilst on the islands. I also thank Kim Goodger (The Natural History Museum, London) for supplying photographs of various specimens in that collection.

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A NEW LOCALITY RECORD AND NOTES ON THE DISTRIBUTION OF *TRAPEZITES WATERHOUSEI* MAYO & ATKINS (LEPIDOPTERA: HESPERIIDAE)

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Abstract

Trapezites waterhousei Mayo & Atkins is newly recorded from Lochada Pastoral Station, north-east of Perenjori, Western Australia. In captivity, larvae readily switched from *Xerolirion divaricata* A.S. George to an alternative food plant, *Acanthocarpus preissii* Lehm. (both Laxmanniaceae). The disjunct distribution of *T. waterhousei* and its *Xerolirion* food plant is discussed.

Introduction

The laterite ochre, *Trapezites waterhousei* Mayo & Atkins, is an endemic Australian skipper restricted to inland southwestern Western Australia, where it has previously been recorded from 11 disjunct localities between Paynes Find and Southern Cross. Colonies are centred around rocky outcrops where the sole known food plant, *Xerolirion divaricata*, occurs (Mayo and Atkins 1992, Williams *et al.* 1996). Adults have always been found in close proximity to this food plant; the life history was recorded by Williams and Atkins (1997).

Recent observations

In July 2003, we found *T. waterhousei* on Lochada Pastoral Station, 75 km north-east of Perenjori. This is approximately 85 km north and west, respectively, of two previously known sites at Breakaway Wells and Paynes Find (Williams *et al.* 1996). At Lochada, *X. divaricata* was growing commonly on a decaying granitic breakaway (28°56'S, 116°50'E) on the eastern boundary of the pastoral station. Searches on the food plants revealed old hatched pupal cases and a number of mid-stage larvae.

The larvae were collected and taken to Perth to be reared in captivity. Before they reached maturity, the supply of *Xerolirion* became mouldy and the larvae were transferred to *Acanthocarpus preissii*, a known food plant for other Western Australian species of *Trapezites* Hübner. The larvae built shelters and fed readily on this alternative food plant before pupating. Adults emerged in October.

Discussion

Acanthocarpus and *Xerolirion* are closely related taxa which formerly belonged to the Dasypogonaceae, a south-west endemic plant family (Hopper and Gioia 2004). Recent genetic work, however, indicates that the contemporary classification for these two genera is in the Laxmanniaceae

[which includes the Lomandraceae] (Stephen Hopper, pers. comm.). *Xerolirion* almost certainly was derived from '*Acanthocarpus*' ancestral stock (Greg Keighery, pers. comm.). *A. preissii* has a near-coastal distribution and is abundant along the west coast of Western Australia, from Dunsborough to North West Cape, with some outlying populations between Bunker Bay and Augusta and at Windy Harbour. By contrast, *X. divaricata* is found only inland, where it is restricted to decaying granitic and lateritic outcrops between Morawa and Southern Cross (George 1986). Populations of *X. divaricata* are disjunct and isolated and, consequently, so are the colonies of *T. waterhousei*. Our observations indicate that adults of *T. waterhousei* are very sedentary and seldom, if ever, move far from their food plants. They would, therefore, be unlikely to travel the large distances between many of the *Xerolirion*-supporting outcrops.

How populations of *X. divaricata* came to be isolated is not clearly understood. It is most likely the result of erosion processes in an old landscape over long periods of time (Greg Keighery, pers. comm.). The area in which *X. divaricata* occurs falls within the 'Southwest Australian Floristic Region', a global hotspot of plant biodiversity (Hopper and Gioia 2004). The region is immensely rich in plant species and origins of this diversity are complex. Recent phylogenetic studies have provided evidence of multiple dispersal events into, out of, and within this floristic region over several million years (Hopper and Gioia 2004). Indeed, many of the region's rare and threatened plant species are now found in disjunct, small populations similar to those of *X. divaricata*.

The fact that *T. waterhousei* is present on these isolated patches of *Xerolirion* suggests that both the plants and butterflies were more widespread in the past. As the range of *Xerolirion* became fragmented, the butterflies were marooned on small islands of food plant. *Xerolirion* grows on largely bare, rocky outcrops and this habit has no doubt reduced its susceptibility to fire, which in turn would have assisted the long-term survival of the butterflies.

That *T. waterhousei* larvae so readily switched to *A. preissii* in the laboratory is intriguing, given that *A. preissii* is essentially a near-coastal species and *X. divaricata* occurs in the semi-arid zone. The plants are 140 km apart at their closest point. *A. preissii* occurs at Mingenew, 50 km east of Dongara (Williams *et al.* 1996), and *X. divaricata* at Lochada Pastoral Station, 140 km further east.

It is interesting to speculate on how long the butterfly colonies might have persisted on these isolated patches of *Xerolirion* food plant. Hopper and Gioia (2004) hypothesised that this semi-arid area, with 300-600 mm of rainfall per annum, was a plant speciation hotspot of late-Tertiary antiquity. Although climatic conditions in southwestern Australia have been remarkably stable for a very long time (Hopper and Gioia 2004), there would have been periods when slightly moister conditions prevailed. If *A. preissii*

(or another *Acanthocarpus* sp.) occurred further inland for a time, it is possible that a temporary 'food plant bridge' may have linked the inland *Xerolirion* and present day near-coastal *A. preissii*. Indeed, there is still a remnant population of *A. preissii* at Mingenew, 50 km from the coast (Williams *et al.* 1993). This might explain the willingness of *T. waterhousei* larvae to feed on *A. preissii*, and might also explain why these long-isolated skipper colonies have not become morphologically distinct.

Phylogenetic studies are needed to better understand the relationships between *Xerolirion* and *Acanthocarpus*, and the Western Australian *Trapezites* skippers *T. waterhousei*, *T. argenteoornatus* (Hewitson), *T. sciron* Waterhouse & Lyell and *T. atkinsi* Williams, Williams & Hay, which utilise them as larval food plants (Williams *et al.* 1998). Similar studies are also required to establish whether there are any genetic differences between the scattered *T. waterhousei* populations.

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THE TAXONOMIC PLACEMENT OF *CAMPIGLOSSA VAGA* HARDY & DREW AND *MESOCLANIS CAMPIGLOSSINA* HERING (DIPTERA: TEPHRITIDAE: TEPHRITINAE)

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Abstract

Campiglossa vaga Hardy & Drew is transferred to *Scedella* Munro (comb. n.). *Mesoclanis campiglossina* Hering [= *Campiglossa turneri* Hardy & Drew, syn. n.] is transferred to *Austrotephritis* Hancock & Drew (comb. n.) and its type locality of 'India or' is regarded as an error [*recte* Western Australia].

Campiglossa vaga

Campiglossa vaga Hardy & Drew, known only from SE Queensland (Hardy and Drew 1996), was provisionally retained in *Campiglossa* Rondani by Hancock and Drew (2003), pending examination of the male terminalia. However, the wing pattern is unlike that of any other Indo-Australian species referred to that genus, where the apical hyaline wing spot, when present, is small and does not fully occupy the apex of cell r_{4+5}. In *C. vaga* the wing pattern is very similar to that of *Scedella* Munro, in which all known Indo-Australian species have a large apical hyaline spot which essentially fills the apex of cell r_{4+5}. Consequently, in order to maintain the morphological separation of the two genera, *Scedella vaga* (Hardy & Drew), comb. n. is transferred from *Campiglossa*. It appears closest to *S. infrequens* (Hardy & Drew), also known from SE Qld, and the two are possibly synonymous.

Mesoclanis campiglossina

This species was described and illustrated by Hering (1944) from a single female from 'India or' [no stop after 'or' on label, *vide* Hardy 1968]. No further Indian material has been recorded. It clearly belongs in *Austrotephritis* Hancock & Drew (2003), not in *Mesoclanis* Munro. *Austrotephritis campiglossina* (Hering), comb. n. closely resembles *A. turneri* (Hardy & Drew) (1996, as *Campiglossa turneri*) which, given the extent of variation in related species, is placed as a new synonym. The stated type locality of *A. campiglossina* is almost certainly erroneous [or incomplete] and the specimen is likely to be of Western Australian origin.

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ABERRANT WING VENATION IN THE GREEN LACEWING *APOCHRYSA LUTEA* (WALKER) (NEUROPTERA: CHRYSOPIDAE: APOCHRYSINAE)

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Abstract

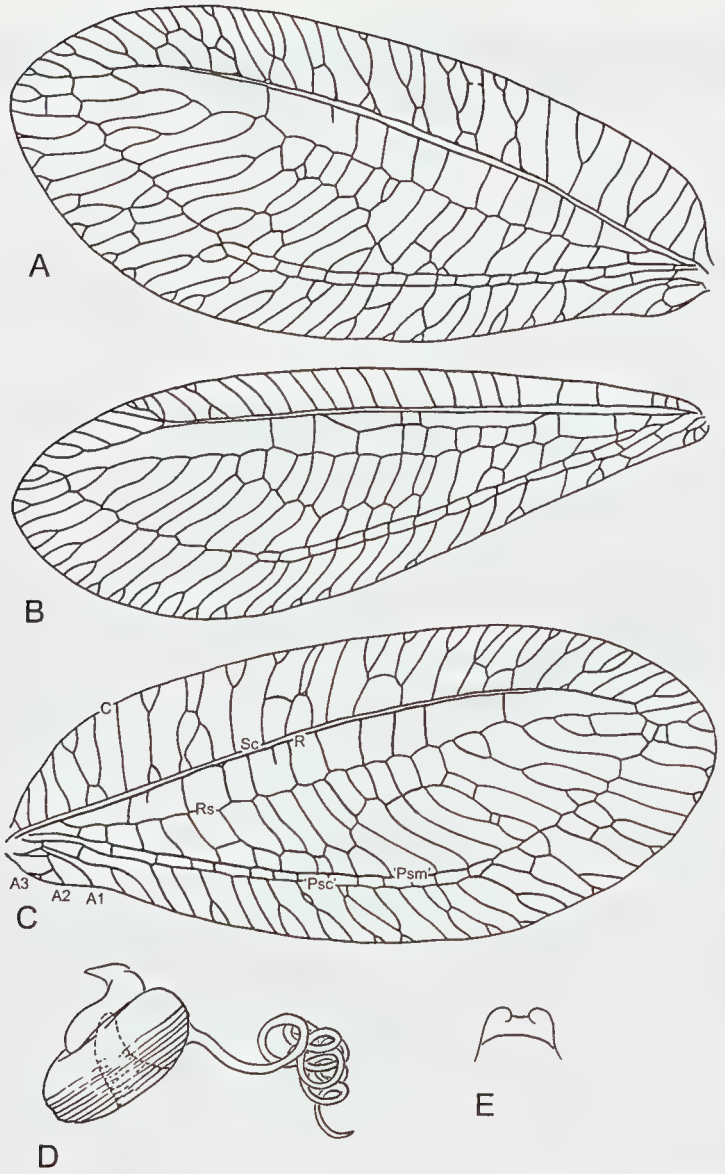
An example of highly aberrant wing venation in a specimen of *Apochrysa lutea* (Walker) from southeastern Queensland is described and discussed in light of recently revised generic definitions in the subfamily Apochrysinae.

Introduction

Members of the green lacewing subfamily Apochrysinae are typically large chrysopids with broad, rounded wings and densely reticulated venation. Apochrysinae are pantropical in distribution, with greatest species richness in the Oriental and Australasian regions (Brooks and Barnard 1990, Winterton and Brooks 2002). Adults are weak fliers and fly with a slow, fluttering motion. They are almost always associated with dense, humid forests (Tjeder 1966, Tsukaguchi 1995, Winterton 1995, Penny 2002). *Apochrysa* Schneider (*sensu* Winterton and Brooks 2002) is an Old World genus represented by four species in Madagascar and southern and eastern Africa, one species in Japan and Taiwan, and six species in eastern Australia, Indonesia and Oceania (Kimmins 1952, Brooks and Barnard 1990, Hölzel 1996, Winterton 2002). Originally divided into six genera (*i.e. Anapochrysa* Kimmins, *Apochrysa*, *Nacaura* Navás, *Oligochrysa* Esben-Petersen, *Lauraya* Winterton and *Synthochrysa* Needham), these were all synonymised with *Apochrysa* by Winterton and Brooks (2002), thereby broadening the definition of the genus.

For many years, the taxonomy and classification of Apochrysinae was considered unsatisfactory, with generic concepts narrowly defined based on wing venation. This resulted in numerous monotypic genera and new species requiring default placement into new genera (Brooks and Barnard 1990, Brooks 1997). In light of this, Winterton and Brooks (2002) used a quantitative phylogenetic analysis to identify likely synonymies throughout the subfamily and reduced the total number of genera from 13 to six. Moreover, they broadened remaining generic concepts so that they were inclusive rather than exclusive in nature, thus allowing newly described taxa to be placed in existing genera rather than requiring the erection of new ones.

A female specimen from Australia, clearly belonging in Apochrysinae but with highly aberrant wing venation, is described and discussed here. Under the previous strict generic definitions, this specimen would probably have been described as a new species in a new monotypic genus but, under the revised concept, it can now be placed in the genus *Apochrysa* simply as an aberrant form of *A. lutea* (Walker).



Fig, 1. Wings of aberrant specimen of *Apochrysa lutea* (Walker): A, left forewing; B, left hind wing; C, right forewing (forewing length = 18.0 mm.); D, spermatheca; E, subgenitale. Abbreviations: *C*, costal vein; *Sc*, subcostal vein; *R*, radial vein; *Rs*, radial sector; '*Psm*', pseudomedial vein; '*Psc*', pseudomedial vein; *A1*, *A2* and *A3*, anal veins.

Apochrysa lutea (Walker)

(Fig. 1)

Material examined. 1 ♀, AUSTRALIA: Queensland: Brisbane, 1933, A.R. B[rimble]combe (in Queensland Department of Primary Industries and Fisheries Collection, Indooroopilly). Condition fair; right hind wing mostly missing, genitalia in genitalia vial attached to pin.

Description (Fig. 1). Wing venation abbreviations are those used by Brooks and Barnard (1990). Forewing length: 18 mm. Wings unmarked; venation pale yellow in old specimen; setae along wing veins relatively long; pterostigma indistinct; vein *C* equidistant with *Sc* along most of length in both wings; forewing costal crossveins irregularly shaped, either simple, forked or fused together (Figs 1A, C), sometimes joined by secondary crossveins, hind wing costal crossveins simple except near apex of wing; *Sc* short, very closely associated with *R* along entire length; *R* and *Rs* joined by simple crossveins along basal half of wing, a single crossvein between the two veins in distal half of wing, several incomplete 'spurious' veins arising posteriorly from *R* in forewing; hind wing with short additional longitudinal vein between veins *R* and *Rs* (Fig. 1B); 'end-twigging' of veinlets along posterior margin of both wings is irregular and shallow; right forewing (Fig. 1C) Cu_2 directed posteriorly and joins posterior margin of wing, thus making cell c_2 open and discal cubital cell (*dcc*) absent; vein 1A simple.

Comments. The above female was collected at Brisbane in 1933 and no other similar specimens have been located in the QDPI&F collection or in any other collections. Venation of left and right forewings in this specimen is asymmetrical. In the right forewing the anterior branch of Cu_2, which normally joins to the *Psc* and gives rise to the cell c_2 and the *dcc*, is directed posteriorly, joining the posterior margin of the wing, thus making cell c_2 open and the *dcc* absent.

Within the Apochrysinae, such venational asymmetry is also present, to a lesser degree, in specimens of *Nobilinus bellula* (Banks) and *Loyola croesus* (Gerstaecker) in the United States National Museum collection (Washington D.C.) (pers. observ.). The wings of the above female fall well within the range of wing lengths recorded for *Apochrysa lutea* (*e.g.* New 1980), ruling out the generation of additional wing cross-veins based on increase in wing area. Moreover, such increases in wing area usually result only in production of secondary cross-veins and not additional longitudinal veins as in this specimen. A possible reason for this aberrant venation could be a developmental malformation, either spontaneous or due to extraneous factors such as limited food supply as a larva or environmental pollutants (Clarke 1993). Until further specimens are collected, indicating that this wing venation is actually fixed and represents a true species, I regard this specimen as merely a malformed individual of *A. lutea*.

The collection locality of this specimen is well within the known distribution of *A. lutea* (coastal areas of northern Queensland to central New South Wales), which is the only species of Apochrysinae known from the Brisbane area. The basic elements of wing venation of *A. lutea* (see New 1980: figs 1-2) can be found in this specimen regardless of the many additional secondary veins. Similarly, the female genitalia are identical to those of *A. lutea* (Figs 1D, E). The distinct asymmetry of the left and right wings also supports the conclusion that the wing venation in this specimen is a malformation of the typical wing venation.

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A LIST OF HAWK MOTHS (LEPIDOPTERA: SPHINGIDAE) FROM EAST TIMOR

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Abstract

Records are provided for 36 species of Sphingidae recently collected from East Timor. Eight species, *Acherontia styx* Westwood, *Agrius luctifera* Walker, *Psilogramma casuarinae* Walker, *Acosmeryx anceus* Stoll, *Gnathothlibus eras* (Boisduval), *Hippotion echeclus* Boisduval, *Theretra natashae* Cadiou and *Amplypterus panopus* (Cramer) are newly recorded from East Timor, bringing the total known fauna of Timor to 38 species.

Introduction

Until recently, very little had been published on the hawk moth fauna of East Timor and the island of Timor in general. D'Abrera (1987) listed available specimens held in The Natural History Museum, London, while several authors (Cadiou 1995, Brechlin 1998, 2001, Brechlin *et al.* 2001) have recently described new species from the Lesser Sunda Islands and adjacent areas.

A recent web page dealing with the Sphingidae of southeast Asia (Beck and Kitching 2005) compiled all available data from this region and listed 30 species from the island of Timor. Of those 30 species, we collected 28, plus an additional 8 species, during two periods (from April-November 2002, by MDL while on a United Nations military deployment, and in January 2004, by DAL and MDL) in East Timor. This brings the total number of recorded species to 38, all listed in Table 1. The two species not observed by us were *Cephonodes picus* (Cramer) and *Macroglossum prometheus lineata* Lucas (Beck and Kitching 2005).

Material was collected from the following localities in EAST TIMOR: Memo, 300 m, 9°01'26"S, 125°11'13"E; Balibo, 570 m, 8°58'07"S, 125°02'33"E; Fatuklaran, 730 m, 8°59'26"S, 125°03'10"E; Bobonaro, 1000 m, 9°00'40"S, 125°21'50"E. Reference material is deposited in the authors' collection, Atherton.

Comments

Periods of hawk moth observation during 2002 were mostly of quite limited duration and location, and are presented as a preliminary guide only to the fauna of those areas. Further collecting and observations will undoubtedly increase species numbers for respective areas. Of the eight newly recorded species (indicated by * in Table 1), *Amplypterus panopus* was observed only as a single specimen. *Cephonodes* species were observed several times in the field but, due to difficult terrain, only a single specimen of *C. hylas* was collected. *Psilogramma casuarinae* was previously recorded from northern and eastern Australia and New Guinea (Beck and Kitching 2005).

Table 1. List of hawk moths recorded in East Timor from April-November 2002 and in January 2004. Localities are abbreviated as: Me [Memo], Ba [Balibo], Fa [Fatuklaran] and Bo [Bobonaro]. Months of observation are listed in roman numerals. Nomenclature follows that of Beck and Kitching (2005). * = new record; ** = known from Timor but not recorded during survey.

Species	Locality	Months	Comments
SPHINGINAE			
Acherontia lachesis (Fabricus)	Ba, Bo	i,v,xi	common
Acherontia styx Westwood*	Bo	i	scarce
Agrius convolvuli (Linneaus)	Me, Ba, Fa, Bo	i,iv,v,vii, xi	common
Agrius luctifera (Walker)*	Bo	i,xi	common
Psilogramma menephron (Cramer)	Fa, Bo	i,iv,xi	common
Psilogramma wetarensis Brechlin	Bo	i,xi	common
Psilogramma casuarinae Walker*	Bo	i	scarce
SMERINTHINAE			
Ambulyx andangi Brechlin	Bo	xi	scarce
Ambulyx moorei Moore	Bo	i,xi	scarce
Clanis euroa Rothschild & Jordan	Fa, Bo	iv,xi	scarce
Marumba timora Rothschild & Jordan	Bo	i,xi	scarce
Polyptychus claudiae Brechlin, Kitching & Cadiou	Bo	i,xi	scarce
Amplyptetus panopus (Cramer)*	Fa	iv	scarce
MACROGLOSSINAE			
Acosmeryx anceus Stoll*	Fa, Bo	i,iv,xi	common
Acosmeryx shervillii Boisduval	Bo	i,xi	scarce
Cephonodes hylas (Linnaeus)	Bo	i	scarce
Cephonodes picus (Cramer)**	Recorded by Beck and Kitching 2005		
Daphnis hypothous hypothous (Cramer)	Fa, Bo	i,iv,xi	common
Daphnis placida (Walker)	Bo	i,xi	common
Gnathothlibus eras (Boisduval)*	Fa, Bo	i,iv,xi	common
Hippotion boerhaviae (Fabricus)	Fa, Bo	i,iv,xi	common
Hippotion celerio (Linnaeus)	Ma, Ba, Bo	i,iv,vi,xi	common
Hippotion echeclus (Boisduval)*	Bo	i	scarce
Hippotion paukstadti Cadiou	Bo	i,xi	common
Hippotion rosetta (Swinhoe)	Bo	i,xi	common
Hippotion velox (Fabricus)	Fa, Bo	i,iv,xi	common
Macroglossum vacillans Walker	Fa, Bo	i,iv,xi	scarce
Macroglossum prometheus lineata Lucas**	Recorded by Beck and Kitching 2005		

Species	Locality	Months	Comments
Pergesa acteus (Cramer)	Bo	i,xi	common
Theretra alecto (Linnaeus)	Bo	i,xi	common
Theretra clotho (Drury)	Fa, Bo	i,iv,xi	common
Theretra incarnata Rothschild & Jordan	Bo	i,xi	scarce
Theretra insignis (Butler)	Bo	i,xi	common
Theretra latreillii lucasii (Walker)	Fa, Bo	i,iv,xi	common
Theretra natashae Cadiou*	Bo	i,xi	common
Theretra nessus (Drury)	Fa, Bo	i,iv,xi	common
Theretra oldenlandiae oldenlandiae (Fabricius)	Bo	i,xi	common
Theretra silhetensis (Walker)	Fa, Ba, Bo	i,iv,v,xi	scarce

In their website, Beck and Kitching (2005) listed *Gnathothlibus eras* and *G. erotus* (Cramer) as separate species, recording *G. eras* from the eastern Indonesian archipelago, New Guinea, Australia and Pacific islands, and *G. erotus* from the western Indonesian archipelago extending into SE Asia, but did not provide characters to support this separation. Males of *G. eras* from East Timor are similar in wing markings to males from Australia, but differ noticeably in leg structure. One of the characters that allows separation of Australian *G. eras* from the endemic *G. australiensis* Lachlan, is a much reduced length and thickness of the long hair scales covering the fore tibia in males of *G. australiensis*, but with much longer and thicker hair scales in males of *G. eras* (Lachlan 2004). Following this character, male specimens of *G. eras* from East Timor appear intermediate between Australian *G. eras* and *G. australiensis*, with quite reduced hair scales, but not as reduced as in *G. australiensis*. Further investigation into the status of Timorese specimens is warranted.

Acknowledgements

Dr M.S. Moulds and Mr R. Lachlan (both Australian Museum, Sydney) and Dr I.J. Kitching (The Natural History Museum, London) are all sincerely thanked for their advice and for comparing digital images with specimens in their care. Dr R. Brechlin (Germany) also compared digital images with specimens in his care and helped considerably with literature sources.

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NEW RECORDS AND NOTES OF HAWK MOTHS (LEPIDOPTERA: SPHINGIDAE) FROM DAUAN ISLAND, TORRES STRAIT, QUEENSLAND

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Abstract

Two species of hawk moth, *Angonyx papuana* Rothschild & Jordan and *Macroglossum hirundo errans* (Walker) are newly recorded from Dauan Island. The previous record of *Hippotion scrofa* (Boisduval) from this island was an error.

Introduction

Lachlan and Knight (2004) provided records for 31 species of hawk moths from Dauan Island (9°25'S, 142° 32'E), Torres Strait. However, the record for one of these, *Hippotion scrofa* (Boisduval), was an error; the specimens were actually from New Caledonia and had been placed inadvertently with Dauan Island material. *H. scrofa* remains unrecorded from the Torres Strait region. One of us (AIK) recently spent approximately 12 weeks, between 15 December 2005 and 11 March 2006, conducting a further survey of the hawk moths of the island. A steady decline in species diversity and abundance was noted during the survey period.

All specimens are in the collection of RBL; some duplicates are held by the Australian Museum, Sydney and the Queensland Museum, Brisbane.

Discussion

Only two additional species, *Angonyx papuana* Rothschild & Jordan and *Macroglossum hirundo errans* (Walker), were recorded during the latest survey. The Papua New Guinea species *Theretra insularis insularis* (Swinhoe) (Fig. 1) was again recorded from a single specimen.

Some species, such as *Gnathothlibus erotus eras* (Boisduval), were extremely common throughout the survey period, particularly females. A very small female (Fig. 2) of a *Gnathothlibus* Wallengren species, with a wingspan of only 7.2 cm and unusually dark hindwings, was collected for the first time. This might be a very rare melanic specimen of *G. erotus eras* or, given its very small size and hindwing colouring, it may prove to be the first recorded female of *Gnathothlibus australiensis* Lachlan (Lachlan 2004). This has yet to be resolved.

All species of *Macroglossum* Scopoli recorded in the 2004 survey were seen or collected in larger numbers throughout the latest survey. There are still four species, recorded by Moulds (1985) from the southern islands of the Torres Strait and with ranges into Papua New Guinea, that have not been recorded, as yet, from Dauan Island.

Figs 1-2. Hawk moths from Dauan Island, northern Torres Strait. (1) *Theretra insularis insularis*; (2) *Gnathothlibus* sp.: possible *G. australiensis* female or a melanic specimen of *G. erotus eras*.

It is interesting to note that, of the 32 species of hawk moths now recorded from Dauan Island, nine species (including the two latest records), were recorded from single specimens only.

Acknowledgements

We are again very grateful to Chairperson Mrs Margaret Mau and her Dauan Island Council for their support and permission to visit the island and conduct this survey of the hawk moths and for providing accommodation. We also thank Mr Carl Pardoe-Matthews for preparing the photographs. For comments on the manuscript we sincerely thank Dr Max Moulds (Australian Museum) and Dr Steve Johnson.

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NEW SPECIES OF THE *POLYRHACHIS (MYRMA) PARABIOTICA* SPECIES GROUP (HYMENOPTERA: FORMICIDAE: FORMICINAE) FROM THE PHILIPPINES

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Abstract

Two new species of the here established *Polyrhachis parabiotica* species group, *P. chapmani* sp. n. and *P. empesoi* sp. n., are described from Negros Island in the Philippines. A key to the known members of the group is provided and the new species are illustrated.

Introduction

During two visits to the Museum of Comparative Zoology at Harvard University, I had the opportunity to study specimens of Philippine *Polyrhachis* Fr. Smith ants collected by James W. Chapman and Domingo Empeso. This material contained two new species that are closely related to *P. parabiotica* Chapman, described in 1963 as the only member of a new monotypical subgenus *Anoplomyrma* Chapman. Hung (1967) considered *Anoplomyrma* to be very similar to the subgenus *Myrma* Billberg, but he did not dispute its validity. Dorow (1995) listed *Anoplomyrma* as a junior synonym of *Myrma* and I agree with this decision but, because of the unique combination of characters found in *P. parabiotica*, I am placing it, and two new species described below, into a separate species group within *Myrma*. All three species are restricted to the Philippines. A fourth species, *P. paracamponota* Wang & Wu from Guangxi, China, is tentatively placed in this group based on its original description, but I have been unable to examine the holotype (or any other material) to confirm its position there.

Abbreviations of institutions (with names of cooperating curators) are: ANIC = Australian National Insect Collection, CSIRO Entomology, Canberra, ACT, Australia (Drs S.O. Shattuck and R.W. Taylor); BMNH = The Natural History Museum, London, UK (B. Bolton); MCSN = Museo Civico de Storia Naturale 'Giacomo Doria', Genova, Italy (Drs R. Poggi and V. Raineri); MHNG = Muséum d'Histoire Naturelle, Geneva, Switzerland (Drs C. Besuchet, I. Löbl and B. Merz); MCZC = Museum of Comparative Zoology, Harvard University, Cambridge, Mass., USA (Dr S.P. Cover); QMBA = Queensland Museum, Brisbane, Qld, Australia (Drs C. J. Burwell and G.B. Monteith); RIFC = The Research Institute of Forest Protection, Chinese Academy of Forestry, Beijing, China (Drs Wu Jian and Zhang Yongan).

Methods

Photographs of specimens were taken by Dr Gary Alpert with a Spot 3RT scanning digital camera attached to a Leica MZ16 stereomicroscope. Images were processed using Auto-Montage (Syncroscopy, Division of Synoptics Ltd, USA) software. All photographs are of the primary types.

References and synonyms of individual species are listed only where relevant to the context of this paper. For full synonymy citations see Bolton (1995) and Dorow (1995). Publication dates and the spelling of species epithets follow Bolton (1995).

Standard Measurements and Indices used in the text are: TL = Total length (the necessarily composite measurement of the outstretched length of the entire ant measured in profile); HL = Head length (the maximum measurable length of the head in perfect full face view, measured from the anterior-most point of the clypeal border or teeth, to the posterior-most point of the occipital margin); HW = Head width (width of the head in perfect full face view, measured immediately in front of the eyes); CI = Cephalic index (HW x 100/HL); SL = Scape length (excluding the condyle); SI = Scape index (SL x 100/HW); PW = Pronotal width (width of the pronotal dorsum measured at the bases of pronotal spines); MTL = Metathoracic tibial length (maximum measurable length of the tibia of the hind leg). Measurements were taken using a Zeiss SR stereomicroscope with an eyepiece graticule calibrated against a stage micrometer. All measurements are expressed in millimetres (mm).

Characters of the *P. parabiotica* species group

The *P. parabiotica* species group, here established, is named after the name-bearing species *P. parabiotica* Chapman. Chapman (1963) failed to give the dignostic characters of his newly established subgenus *Anoplomyrma*, but they can be deduced from the description of *P. parabiotica*, as follows: pronotum armed with well developed, anteriorly directed spines; mesosoma convex with the mesonotum virtually immarginate (except in the new species described below, where poorly developed obtuse margins are evident under certain angles of illumination); propodeum totally immarginate laterally and posteriorly, with no propodeal teeth or tubercles; petiole scale-like, with dorsal margin more-or-less rounded or emarginate medially, laterally delimited by a blunt angle. The characters of the *P. parabiotica* group are essentially those of *Anoplomyrma*, except that the pronotal spines may be reduced to short humeral teeth as in *P. paracamponota*.

Key to workers of the *P. parabiotica* species group

1 Pronotal humeri armed with short teeth ..... *paracamponota* Wang & Wu

\- Pronotal humeri armed with relatively long, anteriorly directed spines ... 2

2 Head, mesosoma and gaster distinctly yellowish-red or light reddish-brown; erect or curved hairs abundant everywhere, including appendages, hairs longer than greatest diameter of eye ..... *parabiotica* Chapman

\- Head and mesosoma black with gaster dark brown or red; numerous erect or suberect hairs present only on head and gaster, hairs shorter than greatest diameter of eye 3

3 Body jet-black and highly polished, with very short, sparse golden pubescence; anterior clypeal margin entire ..... *chapmani* sp. n.

- Body finely shagreened, opaque, with short, appressed, silvery or yellowish-golden pubescence; anterior clypeal margin medially notched ..... *empesoi* sp. n.

Polyrhachis parabiotica Chapman, 1963

(Figs 1, 4, 7)

Polyrhachis (Anoplomyrma) parabiotica Chapman, 1963: 258, fig. 7. Syntype workers, queens in MCZC. Type locality: PHILIPPINES, Negros I., Cuernos de Negros, 1500-4000 ft (J.W. Chapman). [2 workers, queen examined].

Additional material examined. PHILIPPINES: Negros Oriental, Lake Balinsasayao, Sibulan, 30.v.1983 (C.K. Starr & F.P. Godoy) (w) (in BMNH and QMBA).

Dimensions of syntypes (Queen cited last): TL c. 6.30, 6.00, 6.90; HL 1.65, 1.68, 1.78; HW 1.40, 1.40, 1.50; CI 85, 83, 84; SL 1.87, 1.96, 1.96; SI 133, 140, 131; PW 1.06, 1.06, 1.43; MTL 2.03, 2.15, 2.12 (2 workers and queen measured; all specimens, notably the queen, are covered in glue and some measurements are only approximate).

Remarks. Chapman (1963) noted that the type colony of *P. parabiotica* was collected on 12.ix.1948 'in a dead frond of a tree fern. The fern trunk was partly surrounded by a mound nest of *Myrmecaria* [*sic* = ?*Myrmicaria* Saunders] ... Both workers and females closely resemble *Myrmecaria* in color very closely. This is, the only nest I ever found'. Chapman also mentioned that he collected workers and dealate queens of *P. parabiotica* from forays of '*Myrmecaria*' on the Cuernos de Negros at 1500 to 4000 ft altitude for many years. However, the specimens collected at Lake Balinsasayao by Starr and Godoy, lodged in BMNH and QMBA, are the only specimens, besides the types, that I have located in collections.

Polyrhachis chapmani sp. n.

(Figs 2, 5, 8)

Types. Holotype worker, PHILIPPINES: Oriental Negros Prov., Cuernos de Negros Mts, 3600 ft, 30.ix.1942, J.W. Chapman. *Paratypes*: 38 workers, 2 queens, 2 males, data (and nest) as for holotype; 4 workers, 2 queens, data as for holotype except 1942-43, hollow vine. Holotype and most paratype workers, 3 queens and males in MCZC; 3 workers and queen in QMBA; 2 workers in each of ANIC and BMNH.

Additional material examined. PHILIPPINES: Negros Oriental, Cuernos de Negros Mts, 3600 ft (various dates of collection - 1942-1943 and 1948) (J.W. Chapman) (w, ♀, ♂); Mindanao, 11 km W Alanib, (08°03'N, 124°57'E), 1160 m, 9.ix.1978, relict rf. (B.B. Lowery) (w) (in MCZC).

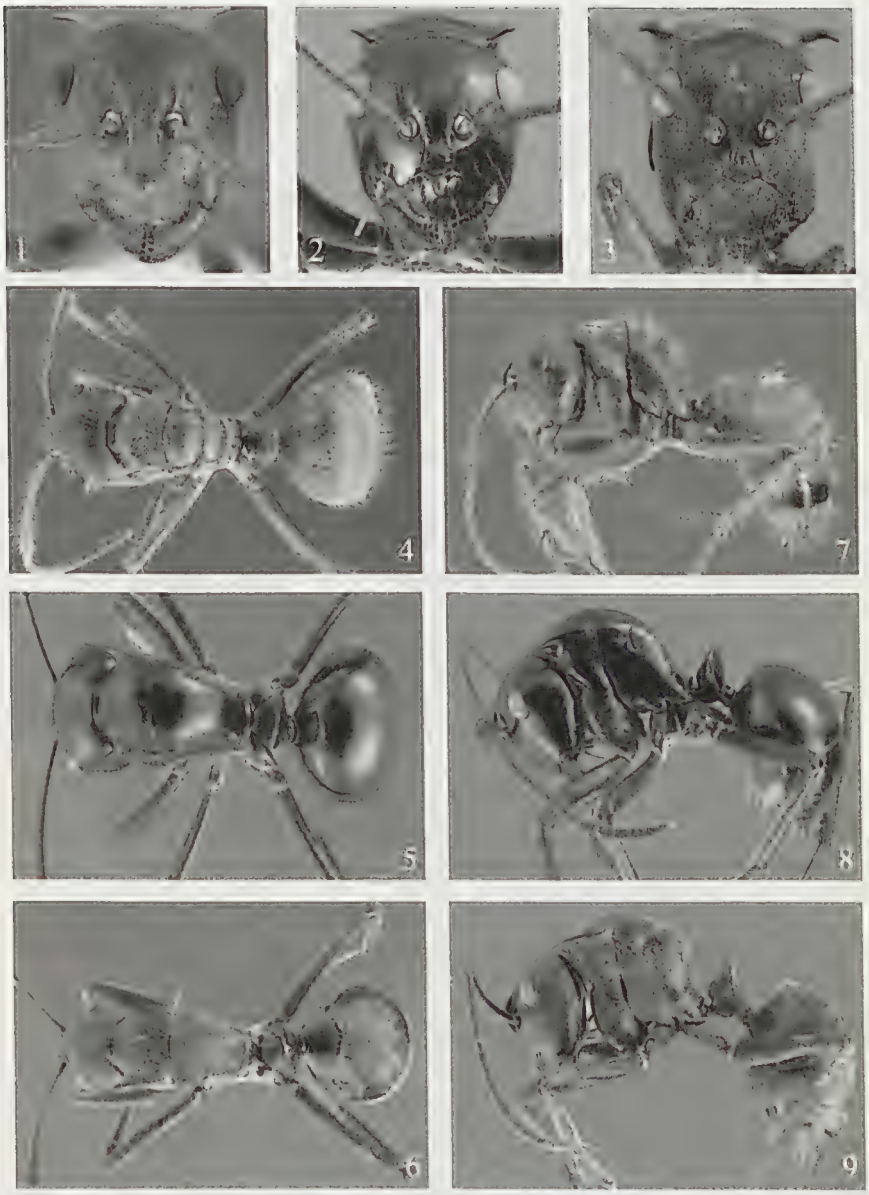
Description. Worker. Dimensions (holotype cited first): TL c. 6.55, 6.00-7.21; HL 1.65, 1.53-1.68; HW 1.40, 1.28-1.43; CI 85, 84-87; SL 2.09, 1.93-2.15; SI 149, 144-154; PW 1.09, 1.03-1.15; MTL 2.15, 2.03-2.28 (18

measured). Mandibles with 5 teeth reducing in length towards base. Anterior clypeal margin arcuate, entire. In profile clypeus straight anteriorly, slightly convex posteriorly with shallow depression just in front of weakly impressed basal margin; laterally basal margin represented by only a thin line. Frontal triangle indistinct. Frontal carinae sinuate with margins at mid length moderately raised and weakly laminate, rather flat and parallel posteriorly. Central area relatively narrow anteriorly, with only barely indicated median furrow. Sides of head in front of eyes almost straight, weakly converging anteriorly towards mandibular bases; rounded behind eyes into convex, medially narrowly emarginate occipital margin. Eyes convex, in full face view exceeding lateral cephalic outline. Ocelli lacking. Pronotal dorsum weakly convex between pair of relatively long, horizontal, anteriorly directed, somewhat dorsomedially flattened spines; lateral margins of spines sharp, continuous with rather blunt lateral pronotal margins that terminate just before reaching promesonotal suture. Mesonotal dorsum with only ill-defined lateral margins; metanotal groove distinct. Propodeum immarginate laterally and posteriorly, without propodeal teeth or tubercles. Petiole scale-like, anterior face weakly convex, posterior face almost flat; dorsal margin rather acute, shallowly emarginate medially. Subpetiolar process in profile rounded anteriorly and posteriorly. Anterior face of first gastral segment lower than height of petiole, with anterodorsal face widely rounding onto dorsum of segment.

Mandibles finely, longitudinally striate with numerous piliferous pits. Body surfaces very finely reticulate, rather polished. Intensity of sculpturation marginally increasing laterally, with sides of mesosoma finely, irregularly wrinkled. Numerous shallow punctures scattered over most body surfaces.

Mandibles with a few short, semierect, yellowish-golden hairs near masticatory borders and very short, appressed hairs towards bases. Anterior clypeal margin medially usually with three longer, anteriorly directed setae and one short seta on each side towards mandibular bases. Several pairs of relatively long, erect hairs near anterior and basal clypeal margins, along frontal carinae and on vertex. A few semierect hairs on anterior face of fore coxae and several shorter, erect hairs on ventral surfaces of femora. Numerous, semierect, somewhat posteriorly directed, relatively long hairs lining posterior margins of most gastral segments, particularly abundant around gastral apex. Very short, closely appressed, golden pubescence, arising from shallow pits, scattered over all body surfaces.

Head and mesosoma black; clypeus, meso- and metapleurae diffusely blotched red or reddish-brown. Mandibles reddish-brown with outer borders and teeth black. Petiole mostly black at base, progressively becoming reddish-brown towards dorsal margin. Antennae, coxae and legs light red or reddish-brown with tarsi and proximal ends of tibiae narrowly black. Gaster red with posterior margins of segments diffusely reddish-brown.



Figs 1-9. *Polyrhachis* spp. (1-3): Head in full face view. (1) *P. parabiotica* Chapman (syntype); (2) *P. chapmani* (holotype); (3) *P. empesoi* (holotype). (4-6): Dorsal view. (4) *P. parabiotica* Chapman (syntype); (5) *P. chapmani* (holotype); (6) *P. empesoi* (holotype). (7-9): Lateral view. (7) *P. parabiotica* Chapman (syntype); (8) *P. chapmani* (holotype); (9) *P. empesoi* (holotype).

Queen. Dimensions: TL c. 7.16-7.71; HL 1.78-1.84; HW 1.50-1.53; CI 83-86; SL 2.09-2.25; SI 139-150; PW 1.47-1.50; MTL 2.28-2.37 (4 measured). Queen very similar to worker with usual differences indicating caste, including three ocelli and complete thoracic structure. Clypeus in profile straight anteriorly, weakly convex posteriorly with basal margin very shallowly impressed. Eyes somewhat larger and more convex than in worker. Pronotal humeri with spines marginally shorter than in worker; mesoscutum wider than long, with lateral margins converging into anteriorly rounded margin; median line short, very poorly indicated; parapsides distinct, rather flat; mesoscutum in profile rounding anteriorly onto flat dorsum; mesoscutellum convex, marginally elevated above dorsal plane of mesosoma; metanotal groove strongly impressed. Propodeum rounded laterally and posteriorly. Petiole, subpetiolar process and anterior face of first gastral segment identical to those in worker. Mandibles finely longitudinally striate. All dorsal surfaces very finely reticulate, rather polished, but not as shiny as in worker. Pilosity similar to that in worker, with appressed pubescence more silvery and somewhat more abundant on pronotum, notably along anterior margin of mesoscutum. Black, with colour scheme virtually identical to that of worker, except appendages and gaster distinctly darker, reddish-brown.

Males and immature stages (larvae and pupae) in MCZC spirit collection.

Etymology. Named in honour of James W. Chapman, who collected many species of ants, including *Polyrhachis*, during his pre- and postwar residence in Dumaguete on Negros I., Philippines.

Remarks. Three of the worker specimens of the type series, originally mounted on a single pin, are furnished with a label inscribed: '*Polyrhachis (Anoplomyrma) negrosensis* sp.n. Chapman'. In spite of this unpublished name evidently proposed by Chapman, I believe that it is more appropriate to name this new species after him.

***Polyrhachis empesoi* sp. n.**

(Figs 3, 6, 9)

Types. *Holotype worker*, PHILIPPINES: Oriental Negros Prov., Dumaguete, 30.iv.1924, J.W. Chapman. *Paratypes*: 12 workers, data as for holotype. Holotype and 4 paratypes in MCZC; 2 paratypes each in ANIC, BMNH and QMBA.

Additional material examined. PHILIPPINES: Negros Or., Dumaguete, Camp Lookout, 1500 ft, 1948 (J.W. Chapman) (♀); same locality, 1950 (J.W. Chapman) (♀); Luzon, Mt Makiling (Baker) (w); Camarines Sur, Mt Iriga, 500 m, 31.iii.1962 (H.M. Torrevillas) (w). Mindanao, Misamis Oriental, Sumay, Gingoog, 25.xii.1950 (Domingo Empeso) (w) (in MCZC).

Description. Worker. Dimensions (holotype cited first): TL c. 6.90, 6.65-7.21; HL 1.75, 1.68-1.75; HW 1.31, 1.28-1.33; CI 75, 74-76; SL 2.18, 2.18-2.28; SI 174, 166-176; PW 1.28, 1.15-1.28; MTL 2.15, 2.06-2.18 (13 measured). Mandibles with 5 teeth reducing in length towards base. Anterior

clypeal margin arcuate, distinctly notched medially. Clypeus with blunt, but distinct median carina; clypeus virtually straight in profile, only very shallowly concave behind anterior margin; basal clypeal margin flat, laterally represented by thin line. Frontal triangle indistinct. Frontal carinae sinuate with margins raised and moderately laminate at their mid length, rather flat and converging posteriorly. Central area relatively narrow anteriorly, with clearly indicated, short, smooth, median line. Sides of head in front of eyes almost straight, only weakly converging anteriorly towards mandibular bases; rounded behind eyes into highly convex occipital margin. Eyes convex, in full face view only marginally exceeding lateral cephalic outline. Ocelli lacking. Pronotal dorsum weakly convex between pair of relatively long, horizontal, anteriorly directed spines; lateral margins of spines blunt, continuous with rather blunt lateral pronotal margins that terminate just before promesonotal suture. Mesonotal dorsum with blunt lateral margins anteriorly, immarginate posteriorly; metanotal groove distinct. Propodeum immarginate laterally and posteriorly, without propodeal teeth or tubercles. Petiole scale-like, anterior and posterior faces almost flat, converging dorsally and forming acute, medially jagged dorsal margin. Subpetiolar process in profile rounded anteriorly and posteriorly. Anterior face of first gastral segment about as high as petiole, very weakly concave at base, with anterodorsal face narrowly rounding onto dorsum of segment.

Mandibles finely, longitudinally striate with numerous piliferous pits. All body surfaces finely, more-or-less uniformly reticulate-punctate with sculpturation only marginally more distinct laterally.

Mandibles with a few short, semierect, yellowish-golden hairs near masticatory borders and very short, closely appressed hairs towards bases. Anterior clypeal margin usually with three longer, anteriorly directed, medial setae and a few very short setae laterally towards mandibular bases. Clypeus with a few pairs of medium length, erect hairs near anterior and basal margins; distinctly shorter, anteriorly bent hairs along frontal carinae. Anterior face of fore coxae with several, long erect hairs; very short, solitary hairs on ventral surfaces of trochanters of mid and hind legs. Numerous, semierect, somewhat posteriorly directed, medium length hairs lining posterior margins of apical gastral segments, distinctly longer hairs along sternites and around gastral apex. Short, closely appressed, silvery pubescence abundant on all body surfaces; somewhat longer on meso- and metapleurae, almost completely hiding underlying sculpturation.

Body black, with mandibular masticatory borders, antennae, legs, including coxae, petiole and gaster, medium to dark reddish-brown.

Queen. Dimensions: TL c. 8.42-8.57; HL 2.06-2.09; HW 1.53; CI 72-73; SL 2.57; SI 168; PW 1.72; MTL (missing) (2 measured). Queen essentially as worker with usual differences indicating caste, including three ocelli and complete thoracic structure. Anterior clypeal margin distinctly notched

medially; clypeus in profile very weakly sinuate, shallowly concave anteriorly, weakly convex posteriorly, before descending into shallowly impressed basal margin. Eyes somewhat larger and more convex than in worker, clearly exceeding lateral cephalic outline. Pronotal humeri with spines marginally shorter than in worker; mesoscutum wider than long, with lateral margins converging into anteriorly rounded margin; median line clearly indicated; parapsides rather flat, weakly raised posteriorly; mesoscutum in profile rounding anteriorly onto flat dorsum; mesoscutellum only weakly convex, marginally elevated above dorsal plane of mesosoma; metanotal groove strongly impressed. Propodeum immarginate laterally; posteriorly rounding into weakly concave declivity. Petiole, subpetiolar process and anterior face of first gastral segment virtually identical to those in worker. Mandibles finely longitudinally striate. All dorsal surfaces with sculpturation and pilosity similar to that in worker. Body with relatively abundant appressed pubescence more yellowish-golden on head and pronotum, pale yellow on dorsum of gaster and silvery on lateral mesosoma and appendages. Head, mesosoma, petiole and gaster black, with mandibular masticatory borders and appendages dark reddish-brown.

Male and immature stages unknown.

Etymology. Named in honour of Domingo Empeso of Silliman University, Dumaguete, Philippines, who collected many *Polyrhachis* species together with J.W. Chapman on Oriental Negros and elsewhere in the Philippines.

Remarks. The two available queens are in poor condition. Both are missing numerous legs with one of them also missing the antennae. They were evidently collected separately from the workers, but their morphological characters and general appearance suggest that they are the queens of *P. empesoi*.

Polyrhachis paracamponota Wang & Wu

Polyrhachis paracamponota Wang & Wu, 1991: 599, 601, figs 3, 7. Holotype worker in RIFC. Type locality: CHINA, Ningming Co., Guangxi Autonomous Region (Zhang Peiyi). [Not examined].

Dimensions of holotype: TL 6.46; HL 1.95; HW 1.65; CI 85; SL 2.53; SI 153; PW 1.40; MTL 2.74 (after Wang and Wu 1991).

Remarks. In spite of my personal communication with Drs Wu Jian and Zhang Yongan, I was unable to examine the holotype (and only known specimen) of *P. paracamponota* lodged in the collection of the RIFC. However, in the original description the authors commented that *P. paracamponota* was allied to *P. parabiotica* Smith (*sic*) from the Philippines, but differed in having the pronotum armed 'with two humeral teeth, not spines'. Dorow (1995) listed *P. paracamponota* within the subgenus *Myrma*. Because of its alleged similarity to *P. parabiotica*, I am provisionally placing it within the *P. parabiotica* species group.

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